9TH JUNE, 1904.

OIL ENGINES.

BY GUSTAVE EY.

THE oil engine is fast becoming one of the most extensive factors in power for all purposes. That it is not taking hold faster is because it is not understood as well as it should be, either by the builders or the users of engines. While there are quite a number of very good engines, there are, unfortunately, a great many more of which it may be said that, while the maker's intentions were good, the results have not fulfilled their intentions. The steam engine has so long been a factor in our industrial life that it has ceased to be looked upon with awe, and anyone with the least pretensions to a knowledge of engineering understands the general principles of operation of the older motor. While the gas engine is simple, and, in fact, much less complicated than the steam engine in so far as its mechanism is concerned, it is but imperfectly understood, even by many who have had close dealings with it for years. Owing to the fact that an oil engine is self-contained and produces the propulsive force from the fuel as it is needed, the derangement of any function is very likely to throw the entire motor out of working order. While much more is usually expected of the oil engine than of the steam engine, the previous assertion is none the less true that reliability of operation is the primary consideration, and by all means the most important.

The object of this paper is to briefly give an explanation of the principles of an oil engine.

The oil motor is sometimes referred to as a hydro-carbon motor, an internal combustion motor, or an explosion motor. These last three terms are broader than "oil motor," as they cover some that are not oil motors.

The primary principle on which the oil motor operates is as follows:—

Oil vapor mixed with air to form an explosive mixture is introduced into a cylinder, in which a piston can move forwards and backwards. The mixture is compressed in the cylinder behind the piston so as to occupy only one-third to one-quarter the space it would occupy at atmospheric pressure. The mixture is then ignited by an electric spark or hot tube. The combustion of the mixture increases its pressure about four times, and under this increased pressure the piston is forced outward, and power is transmitted to a crank to which the piston is connected. It will be seen from this that various operations succeed each other in the cylinder. The combustible mixture is ignited and expanded, and finally the gas which forms the product of combustion must be exhausted. These various operations are repeated periodically, and a single performance of all of them is called a cycle. The various operations comprising a cycle may be performed in relative periods of time, and the whole cycle may be performed in the time corresponding to different angular motions of the crank, which gives us the various cycles that are spoken of in connection with oil engines.

A two-cycle engine is an engine in which all the operations in the cylinder comprising a cycle are performed in one revolution of the crank or in two strokes of the piston. A four-cycle engine is an engine in which these operations are performed in two complete revolutions of the crank or four strokes of the piston. The four-stroke cycle is often called the Otto cycle or the Beau de Rochas cycle. It was first suggested by Beau de Rochas, and first practically applied in engines by Otto.

THE OTTO CYCLE.

The diagrams, Plate I., Figs. 1 to 4, will more fully explain the Otto cycle and the operation of engines working according to it.

In these sketches, A is the engine cylinder, located in this cylinder is a piston B in the form of a hollow cylinder open at one end, and attached by a connecting rod C, to the crank D. The space in the cylinder, behind the piston, communicates with the valve chamber E, through the part F, and from the valve chamber lead the two passages G and H, closed by valves I and J, for the admission of gas and the exhaust respectively.

In Fig. 1 the dotted line across the cylinder marks the extreme inner position of the piston. It will be noticed that when the piston occupies this position there is still a considerable free space in the cylinder behind the piston. This space, called the compression space, is now filled with air or gases at atmospheric pressure. Now let us suppose the piston to move forward from this position, which it is shown to have done in Fig. 1. This motion of the piston creates a partial vacuum in the cylinder and causes a disturbance of the equilibrium of pressure on the inside and outside of the walls bounding the space behind the piston, the outer pressure being in excess. The valve I. is arranged to open inwardly, and is normally held down to its seat by a light coiled spring. When the pressure on the inner face of this valve is reduced by the forward motion of the piston, the excess of the pressure on its outer face overcomes the pressure of the spring, and the valve opens. In other words, the valve is opened by the suction of the piston, and is therefore called a suction valve, or an automatic valve. The suction of the piston continues till it reaches the extreme forward position, and during the entire stroke explosive mixture is drawn or sucked into the cylinder through the passage G, which leads from the carburetter in which the mixture is formed. When the piston reaches the extreme forward position the suction ceases and the intake valve now closes under the action of the spring. The cylinder is now filled with a charge of explosive mixture at atmospheric pressure. During the next backward stroke of the piston both the valves leading into the cyclinder are closed, and the charge is compressed in the compression space, reaching a pressure of from 50 to 80 pounds per square inch when the piston is in the extreme position, depending upon the relative size of the compression space.

About this time an electric spark is caused to pass between two spark terminals in K. The compressed charge is thereby ignited; it rapidly burns in the cylinder and increases the pressure four of five times. This drives the piston forward, and during this, the third stroke, the burnt gases expand and transfer a large part of their energy to the piston, from which it is transmitted through the connecting rod to the crank shaft. At the beginning of the next backward, or the fourth stroke the exhaust valve is opened by mechanism connected with the crank shaft. It remains open until the piston reaches the extreme upper position, and during the entire stroke the burnt gases are forced out through the exhaust valve by the receding piston. At the end of the stroke the exhaust valve closes, and this completes the cycle.

The four strokes of the Otto cycle are therefore as follows:—First stroke, suction or induction stroke; second, compression stroke; third, expansion or power stroke; fourth, exhaust stoke. Power is therefore developed in the cylinder in one stroke out of four only. In order that the motor may give off power continuously it is provided with a heavy fly wheel, which stores up energy during the power stroke and gives it off during the other three strokes.

TWO-STROKE CYCLE.

Engines operating on the two-stroke cycle are, as a rule, arranged as shown in Fig. 5. The crank case forms a closed chamber, into which the pipe carrying the explosive mixture leads. The opening of this pipe into the case is closed by an automatic valve. When the piston moves upward the suction caused thereby in the crank case opens this valve, and draws a certain quantity of the explosive mixture into the crank case. During the next downward stroke of the piston this charge in the crank case is slightly compressed.

The crank case is connected to the cylinder by a passage, the opening into the cylinder being uncovered by the piston at the end of its downward stroke. The cylinder exhausts through a port on the opposite side, also uncovered by the piston but a little earlier than the admission port.

Now, suppose that by turning the crank over by hand, a charge has been drawn into and compressed in the crank case, and that the piston is at the lowest point of its stroke. The passage between crank case and cylinder being open, and the pressure in the crank case above atmospheric, some of the charge will pass from the crank case into the cylinder. To prevent this charge from passing out through the exhaust port, at the opposite side of the cylinder a deflector plate is fastened to the piston opposite the admission port to deflect the current of the incoming charge upward.

During the upward stroke of the piston the charge is compressed in the cylinder, and at the end of this stroke it is ignited by an electric spark. Simultaneously additional mixture has been drawn into the crank case. During the next or downward stroke of the piston the gases in the cylinder expand and impart some of their energy to the piston. When the piston reaches the position indicated by the dotted line the exhaust port is uncovered, and the gases, which are still at a considerable pressure, rush out of this port. A little later in the stroke, when the piston reaches the point indicated by the lower dotted line, the intake port opens, and as the pressure in the cylinder has by this time been greatly reduced by the exhaust, the compression in the crank case fills the cylinder with a new charge

In a two-cycle engine then, the charge is compressed during the inward stroke, and burnt during the outward stroke of the piston. Admission and exhaust take place almost simultaneously during the last part of the outward and the first part of the inward stroke. The crank case serves the purpose of a pump to force the charge into the cylinder, which is made necessary by the absence of a suction stroke.

While this engine has many good points, a four-cycle engine out-ranks it when *all* points are considered, and has proved its superiority by every-day practical service; the objection to the two-cycle motor is that all the functions of intake, compression, ignition and exhaust being performed in a single revolution, sufficient time is not allowed for the expulsion of the burned gases, with the result that the cylinder "chokes itself up" as the saying is, and its contents fall below the explodable point, stopping the engine. It is thus estimated that while a four-cycle engine of given horse-power will run at as high a speed as 1200 or 1500 revolutions per minute, a two-cycle engine of the same power can make no more than 400 or 500 revolutions. The same defect in operation prevents the two-cycle motor from attaining the power efficiency otherwise seemingly involved in its constructional theory

Carburetter and Vaporizer.

For a marine gasoline engine, the "Vaporizer" is usually to be preferred to a carburetter, and as these instruments are very often confused, and their meaning is not clearly understood by everyone, an explanation is necessary. A "Carburetter" is an instrument by means of which a portion of air which passes to the engine is enriched with vapor by passing this air either over or through a considerable body of the liquid.

A "Vaporizer" is a device which is employed to transform a small quantity of the gasoline to a finely divided spray, which usually turns at once to a vapour. It differs from the carburetter, in that it transforms the fuel into vapour only as it is needed, and vaporises only the exact quantity required for a single charge, while the carburetter always contains a quantity of vapor from which a supply is drawn to the cylinder. Carburetters are wasteful of fuel, in that they only vaporize its lighter constituents, leaving a useless residue which has to be thrown away. They are also very sensitive to changes of temperature, and in extremely cold weather it is necessary to heat either them, or the air that passes through them, in order that they may work properly. A properly designed vaporizer, on the contrary, is subject to none of these troubles, and on a marine engine they prove themselves much more convenient and easy to handle.

IGNITERS.

The "make and break" electrical methods is practically the same as is used for gas lighting in private residences. The circuit breaker is connected in series with a battery and spark coil. When the circuit is completed the current passes and magnetizes the iron wire core of the coil. On breaking the circuit the instant collapse of the magnetic lines of force into the iron core creates, by the well-known phenomenon induction, an electric pressure in the circuit greatly in excess of that due to the battery and prolongs the flow of current for a considerable distance through the air between the rapidly separating contacts.

The circuit breaker inside the cylinder is variously constructed by different makers, but all have practically the same parts, one stationary and insulated electrode and one movable electrode connected to some rotating or reciprocating part of the engine, so that it shall make and break contact with the fixed electrode at the proper time.

The method of ignition by a secondary or "jump" spark requires less mechanism on the engine. The principle is that when a rapidly interrupted current is sent through the primary coil of a Ruhmkorff or induction coil, it will produce in its secondary coil a current of sufficient force to jump the space between the two fixed and insulated electrodes.

The hot tube is one of the best known methods of indirect flame ignition; when first brought into use it was thought desirable to have its action under control of a valve, but further experience with hot tube igniters developed the fact that a timing valve was not necessary. The regulation could be effected by varying the distance that the fresh charge must travel up the tube before reaching the igniting surface.

But, as may easily be seen, there is a great objection to having an open lamp or burner.

Therefore, it has been the author's aim for a long time to obviate the burner, and still stick to the tube; the easiest way to do this is to insert the tube into the exhaust valve, so as to make the hollow of the tube, part of the combustion chamber. The outpassing burnt combustives keep the tube almost red hot, and as soon as the piston makes its compression stroke the charge is forced into the tube and ignites.

Although this way of using the tube does not entirely do away with the electrical igniter, as the engine only runs on it, as soon as the tube is hot enough, it makes possible "at a small outlay" another ignition apparatus, and it saves the battery from getting run out through constant use while the engine is running.

Gasoline, Benzine, Naptha, and the kindred Hydro-carbons are products of crude mineral oil. They are separated from the crude oil by a process of distillation. The process is very similar to that of generating steam from water.

Crude mineral oil subjected to heat gives off in the form of vapor such products as Gasoline, Benzine, Naptha, etc. The degrees of heat at which these products are separated are comparatively low. Various degrees of heat will separate distinct products.

Gasoline, which is ordinarily supposed to test about 74 degrees, is the quality best adapted for use in the oil engine, although the author had engines running successfully on Gasoline testing anywhere from 60 degrees to 88 degrees. Distillate, which might be called a low grade of Gasoline, and which the author is advised has a flash test about 55° F., is successfully used to operate the majority of gas engines in California. The consumption of oil per B.H.P. is about one-tenth of one gallon per hour.

The ratio of B.H.P. to the indicated H.P. in oil engines range from 70% to 90%, all depending on workmanship.

H.P.

may be calculated by multiplying (A) the area of one piston in square inches by the number (N) of cylinders, multiplied by the stroke (S) in feet, multiplied by the number of revolutions (R) per minute, and divided by a constant (C) of 1000 for four-cycle and 900 for two-cycle engines.

Horse Power : $\underline{A \times N \times S \times R}$

* * *